SPECTRUMASTRO

TCP/IP ROUTER

FOR SPACE APPLICATIONS

24 June 2004

MMC04CB03C

PRESENTED BY:

JIM JOSEPH

TCP/IP ROUTER DEVELOPMENT PROGRAM

Spectrum Astro Responded to the AIST NRA With a Proposal to Develop a Space Router

- Topic Area: Onboard Data Processing
- Subtopic Area: High Speed Intra-Spacecraft Communications Bus

Studies

- Routing Protocols
- Embedded/Flight Processor Use Comparison
- Console Port Implementation
- Router Status and Management

New Hardware Development

- Console Port
- Embedded Routing Processor
- Board Tested to Thermal and Mechanical Qualification Levels

New Software Development

- Routing Software Running on Embedded Processor

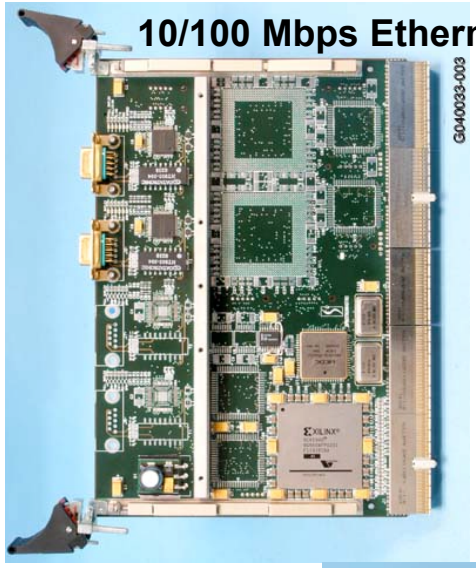
SPACE NETWORK DEVICE DEVELOPMENT

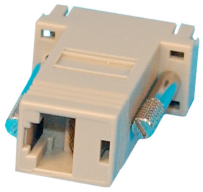
SPECTRUMASTRO

SND (Space Network Devices)

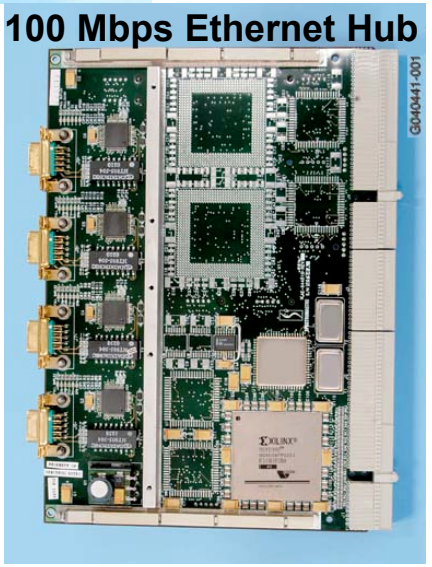
- Customer: NASA/CICT/SCP
- Technical Manager: Robert Jones (NASA GRC)
- TRL 1 - 3
- Goals:
  - Perform Trade Study of Ethernet, FireWire, and SpaceWire Technologies for Use Onboard Spacecraft
  - Develop Prototype Network Hardware for Unmanned LEO Spacecraft
    - » Ethernet Network Interface Controller (NIC)
    - » Ethernet Hub
  - Identify Transitional Architectures to Move From Spacecraft Busses of Today to Next-Generation Networked Spacecraft

10/100 Mbps Ethernet NIC





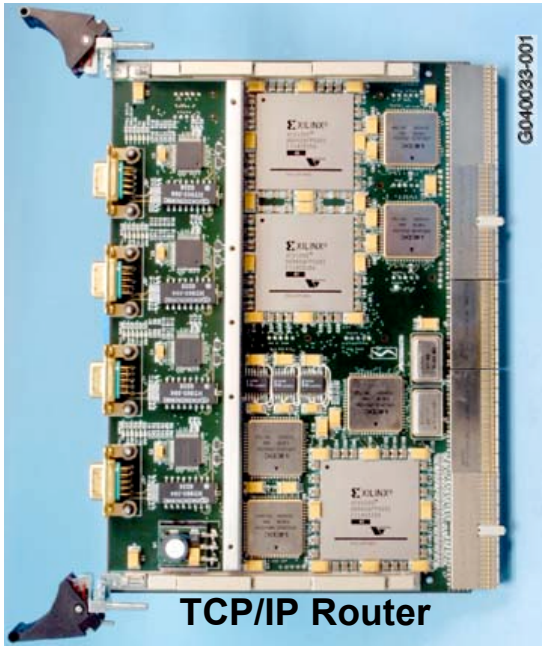
100 Mbps Ethernet Hub



TCP/IP ROUTER DEVELOPMENT PROGRAM

Space Network Router (SNR) - TCP/IP Router With Ethernet Ports

- Customer: NASA ESTO
- Technical Manager: Robert Jones (NASA GRC)
- TRL 3 - 6
- Goals:
  - Perform Trade Studies on Routing Protocols, Internal vs. External Processor, Console Port Implementation, Router Status and Management
  - Develop a Single Board Ethernet Router With Embedded Processor for Use in Unmanned LEO Spacecraft
  - Take Technology Developed Under SND and Transition From Prototype to Flight Hardware

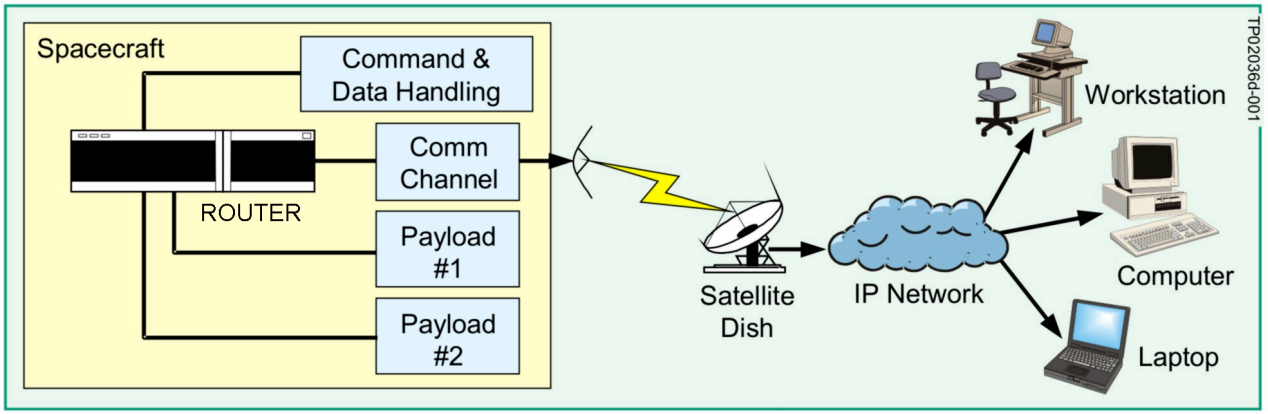


TCP/IP Router

TCP/IP ROUTER

Relevance to Earth Science Enterprise (ESE) Programs

- **NASA Acquires, Processes, and Delivers Large Volumes of Remote Sensing and Related Observations**
- **An Advance in Information Technology (IT) Is Key to Collecting, Handling, and Managing That Data and Information in Space as Well as on the Ground**
- **A Router Allows Increased Accessibility of Earth Science Data By Providing Direct Path to Instruments**
- **A Router Provides a Means to Isolate the Data Requirements While Providing a Selective Path for Communications Between LANs**



Conceptual Space-to-Ground Spacecraft Implementation

BENEFITS OF A ROUTER ON A SPACECRAFT

Interfaces Devices With Different Link and Physical Protocols

- An Internet Protocol Packet Received by a Router Can Be Routed to Devices Using Ethernet, Firewire, Spacewire, MIL-STD-1553, HDLC, SCPS, LVDS, or RS-422
- Payload Providers Can Use a Link/Physical Layer Protocol Appropriate to Their Application That Supports TCP/IP and Allow the Router to Perform the Translation

Interfaces Devices With Different Data Rates

- Slow Devices and Fast Devices Can Communicate Because the Router Performs the Data Rate Translation
- Device Priority Can Be Changed for Different Mission Phases

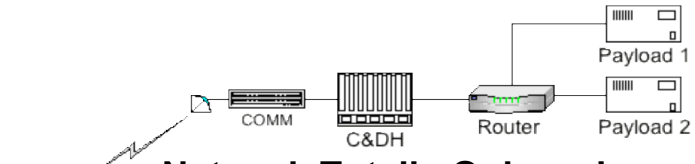
Router Performs Part of the Communications Task for the Flight Processor

- Flight Processor Generates IP Packets and Sends Them to the Network Port. The Router Determines the Appropriate Path and Link/physical Layer Protocol to Send the Message to the Intended Destination
- The Router Performs the Specialized Communications Tasks
- Ground Support Can Communicate Directly With a Payload Without Requiring Intervention by the Flight Processor

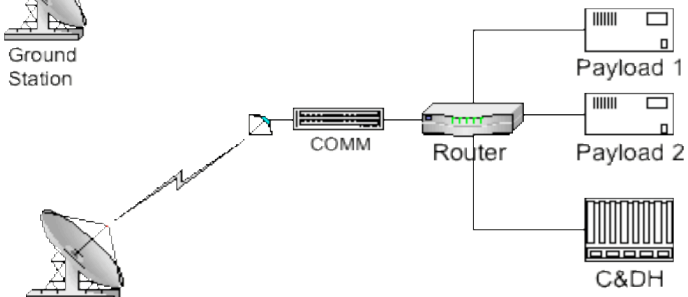
OVERVIEW OF ROUTER STUDIES (1/3)

Routing Protocols

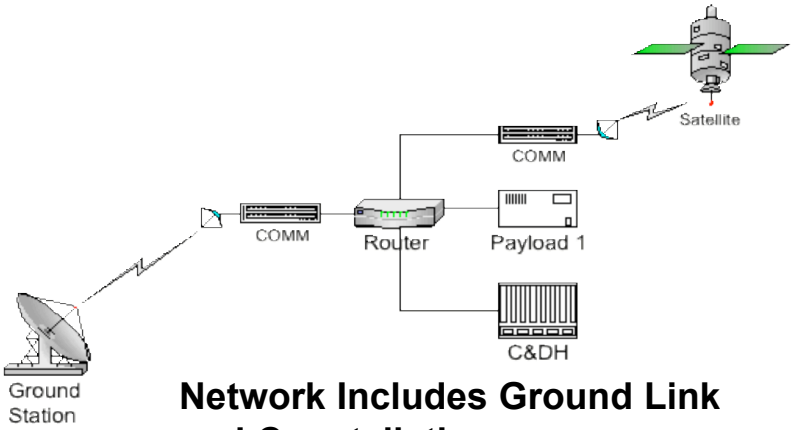
- Routing Information Protocol (RIP)
  - Simple and Suitable for Small Autonomous Networks
- Open Shortest Path First (OSPF)
  - Uses More Memory Resources
  - Benefits for Hot-standby Redundancy
  - Suitable for Hierarchal Networks Where Routing Is Simpler Within Areas and More Complex in the Backbone Network
- Border Gateway Protocol Ver. 4 (BGP-4)
  - Serves the Needs of Large Networks
  - Typically Used by Internet Service Providers
- Mobile IP Protocol
  - Useful When Connections Make and Break in an Unpredictable Manner
  - Relatively Immature and Limited Software Availability



Network Totally Onboard



Network Includes Ground Link



Network Includes Ground Link and Constellation

OVERVIEW OF ROUTER STUDIES (2/3)

Internal/External Processor

- Considered Using C&DH Flight Processor, Processor Chip on Board, Processor Embedded in FPGA
- Selected Embedded Processor
  - Allows Router to Be a Stand-alone Board
  - Allows Software to Be Designed Specifically for Routing
  - Radiation Characteristics Determined by FPGA

OVERVIEW OF ROUTER STUDIES (3/3)

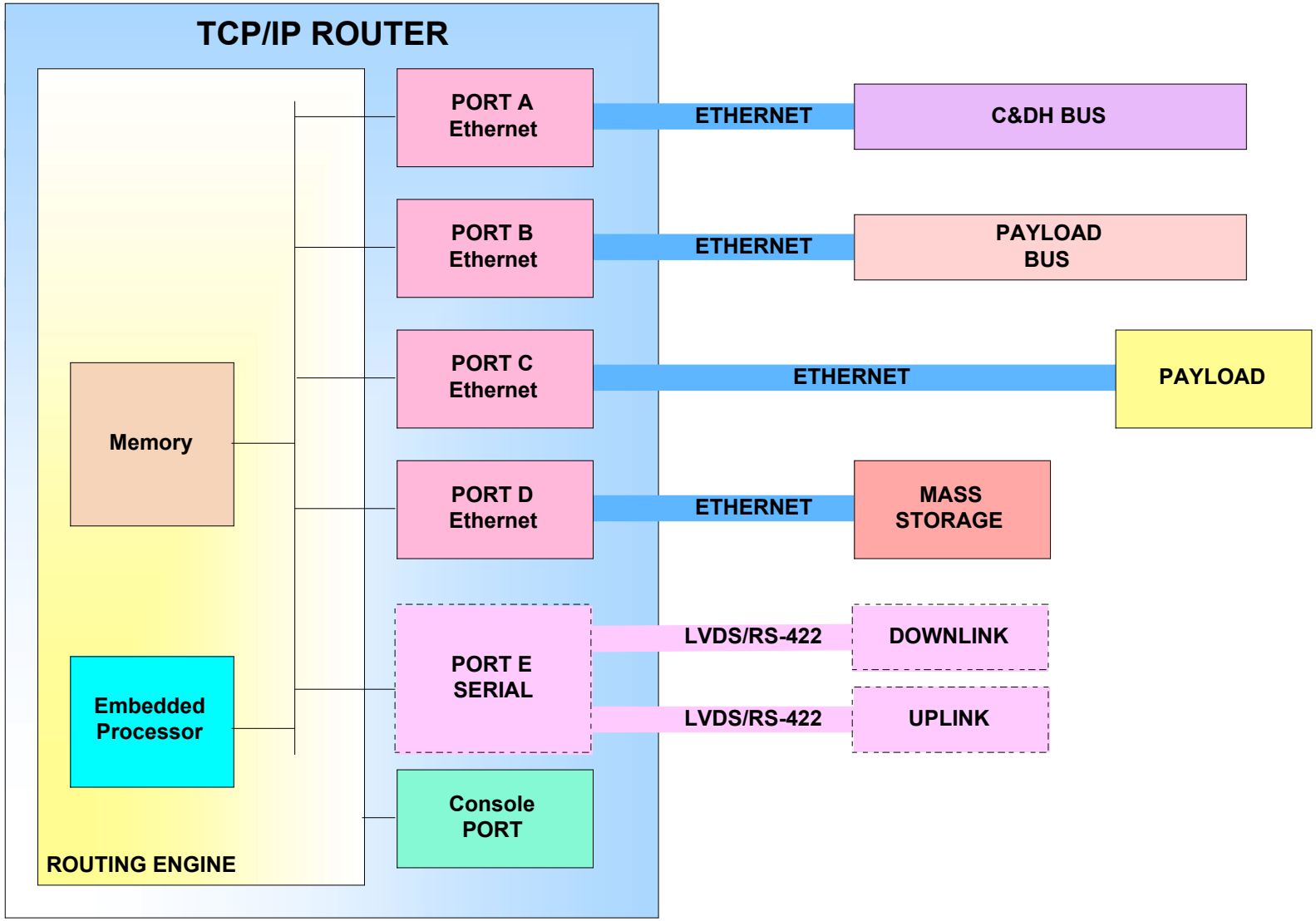
Console Port Implementation

- Provides Configuration Control and Diagnostics Capability for Router
- Alternatives Considered: Direct Serial to Ground, Serial to Flight Processor, Backplane to Flight Processor
- Selected Serial to Flight Processor
  - Allows Router to Be a Stand-alone Board
  - Allows Flight Software to Autonomously Change Router Configuration for Different Mission Phases
  - Still Allows Ground Access to Router Through Flight Software

Router Status and Management

- Management Information Base (MIB) Is Accessed Through Router Ports in Terrestrial Environment
- Console Port Was Chosen to Access MIB for This Implementation
  - Allows MIB Access When Uplink/downlink Is Not Implemented As a Router Port
  - Flight Processor Can Gather MIB Information and Include As Subframes in Normal Telemetry Packets

TCP/IP ROUTER



DESIGN CHALLENGES

Challenges to Designing Space Electronics Based on Terrestrial Network Standards:

- Identifying Parts That Will Meet Space Requirements When Most Parts for LAN Interfaces Are Manufactured for Commercial or Industrial Market at Best
- Identifying Parts Not Expected to Reach End of Life in a Relatively Short Time
- Establishing a Good Working Relationship With Commercial Parts Suppliers
- Determining Approaches to Mitigate Risk, Such As RAM Scrubbing and Redundancy

Our Approach:

- Use Military/Space-Rated Parts in Design Where Possible and COTS Parts Elsewhere
- Validate Use of COTS Parts With Testing and Analysis (Radiation, Thermal Cycling, Etc…)
- Identify and Perform Tests That Verify the Design as Well as Manufacturing Processes
- Identify and Address Issues As Early As Possible in the Design Cycle

SPECTRUMASTRO

SPECTRUM ASTRO

Spectrum Astro Is a Contractor Who Builds Spacecraft for NASA and the DoD

Our Goals

- Providing Competitively Priced Products
- Providing Reliable Schedules
- Improving Integration and Test

How We Achieve These Goals

- Use of Open Standards As Much As Possible
- Limit Custom Hardware or Software Interfaces
- Use COTS Test Equipment to Avoid the Cost and Schedule Hits of Designing and Building Custom Test Equipment
- Flexible Architectures

Spectrum Astro Was the First Aerospace Company to Fly a Bus Based on a Terrestrial Standard (VME)

Use of Open Terrestrial Standards Like TCP/IP and Enabling Technologies Such as Ethernet Are Part of the Evolution For Next-Generation Spacecraft

CONCEPTUAL TECHNICAL DEMO BLOCK DIAGRAM

SPECTRUMASTRO

Allows Operational Programs to Select and Use Technology Without High Risk Penalty

First Technology Demonstration Flight -> Secondary Payload on a Host Spacecraft

Attitude, Power, Mechanical, Thermal Support From Host